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Research on Supply Quantity Transportation and Ordering Model Based on TOPSIS and Support Vector Regression

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Abstract: *For the ordering and transportation of raw materials, we should focus on the production efficiency of the enterprise, that is, the purchasing cost of raw materials, the stability of supply, and the loss rate of transportation. Feature engineering is carried out according to the relevant data to generate more supply features, and the evaluation model uses TOPSIS combined with entropy weight to give the supplier ranking. First of all, this paper makes a quantitative analysis of the supply characteristics of suppliers and uses Python to deal with the order quantity and supply quantity data of the suppliers. Based on this, the data mining work is carried out, and the supply characteristics are analyzed quantitatively. And use TOPSIS combined with entropy weight to give the top 50 most important suppliers, and then work out the most economical raw material ordering plan and the least loss transfer plan in the next 24 weeks. Using SPSS software, the descriptive statistics related to the transport loss rate are obtained. Combined with the data analysis of the loss rate, the corresponding ranking of transporters is obtained by using the entropy weight method, and the 0-1 integer programming is constructed for the transshipment scheme. Support vector regression algorithm model is used to predict the most economical raw material ordering plan per week in the next 24 weeks. This paper provides a reference for the ordering and transportation process of raw materials in enterprises.*

Keywords: *TOPSIS Entropy weight, 0-1 programming, support vector regression*

1. Introduction

As we all know, the supply chain system, that is, raw material cost and transportation is very important for enterprises. Therefore, this paper collects the relevant data of a production enterprise for analysis, hoping to get the optimal supply chain model. In this paper, the raw materials used by enterprises in the production of plates are mainly of three types. The enterprise arranges production according to 48 weeks every year, and needs to make a 24-week raw material ordering and transfer plan in advance, and determine the "supplier" be ordered and the corresponding weekly "order quantity" of raw materials according to the production capacity requirements. As a result, the "transporter" is determined and the weekly "supply volume" of the supplier is transferred to the enterprise warehouse.

2. Model preparation and data preprocessing

In this paper, Python is used to deal with the data of nearly 5 years, and the supply characteristics of 402 suppliers are quantitatively analyzed and data mining. Based on the quantitative analysis and data mining of the supply characteristics of 402 suppliers, the difference, deviation, standard deviation, and material classification between order quantity and supply quantity are considered on the premise of ensuring the importance of enterprise production.

3. Index Evaluation system based on Entropy weight

Considering the difference, deviation, standard deviation, and material classification between order quantity and supply quantity, the entropy method is used to determine the score of the evaluation system. The entropy weight method is an objective weighting method, which means that the weight can be told from the data itself. Based on the superior and inferior solution distance method (TOPSIS), we add the

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entropy method to correct it to avoid the deviation caused by a single method. The smaller the degree of variation of the index, the less the amount of information reflected, and the lower the corresponding weight should be [1].

3.1. Model building

The data collected in this paper are divided into three categories of ABC, in which Category An and Category B raw materials (purchase unit price) are 20% and 10% higher than Category C raw materials, respectively, and the unit costs for transportation and storage of the three types of raw materials are the same. Suppose that the unit values of A, B, and C are 1.2, 1.1, and 1. Each cubic meter of products needs to consume 0.6 cubic meters of Class A raw materials, or 0.66 cubic meters of Class B raw materials, or 0.72 cubic meters of Class C raw materials. The production capacity per unit volume is 0.66, 0.66, and 0.72 per unit volume, respectively. By introducing the preliminary value calculation as the production capacity per unit volume divided by the unit value, it is concluded that the preliminary value calculations of A, B, and C are 1.3889, 1.3774, and 1.3889 respectively. Considering the actual value estimation as the preliminary value minus the transportation and storage cost, it is assumed that the transportation and storage costs of the production unit capacity are 0.06, 0.066 and 0.072 respectively, and the actual value estimates are 1.3289, 1.3114, and 1.3169 respectively.

3.2. Index evaluation process

Through the data mining of suppliers by Python, 10 characteristic indexes (supply characteristics) are obtained: order quantity STD, order quantity MAX, order quantity SUM, supply quantity STD, supply quantity MAX, supply quantity SUM, deviation STD, deviation MAX, deviation MIN, and deviation SUM. Below, there are 402 evaluation targets (402 suppliers), and the positive matrix composed of 10 evaluation indicators is as follows:

$$X = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1,10} \\ x_{21} & x_{22} & \cdots & x_{2,10} \\ \vdots & \vdots & \ddots & \vdots \\ x_{402,1} & x_{402,2} & \cdots & x_{402,10} \end{pmatrix} \tag{1}$$

The normalized matrix is denoted as, where each element is:

$$Z_{ij} = x_{ij} / \sqrt{\sum_{i=1}^{402} x_{ij}^2} \tag{2}$$

Then define the distance between the maximum value, the minimum value, and the maximum and minimum value.

$$\begin{gathered} Z^+ = \left(Z_1^+, Z_2^+, \cdots, Z_{10}^+\right) = \\ \left(\max\left\{z_{11}, z_{21}, \cdots, z_{402,1}\right\}, \max\left\{z_{12}, z_{22}, \cdots, z_{402,2}\right\}, \cdots, \max\left\{z_{1,10}, z_{2,10}, \cdots, z_{402,10}\right\}\right) \end{gathered} \tag{3}$$

$$\begin{gathered} Z^- = \left(Z_1^-, Z_2^-, \cdots, Z_{10}^-\right) = \\ \left(\min\left\{z_{11}, z_{21}, \cdots, z_{402,1}\right\}, \min\left\{z_{12}, z_{22}, \cdots, z_{402,2}\right\}, \cdots, \min\left\{z_{1,10}, z_{2,10}, \cdots, z_{402,10}\right\}\right) \end{gathered} \tag{4}$$

$$D_i^+ = \sqrt{\sum_{j=1}^{10} \left(z_j^+ - z_{ij}\right)^2}\ ,\ \ D_i^- = \sqrt{\sum_{j=1}^{10} \left(z_j^- - z_{ij}\right)^2} \tag{5}$$

The unnormalized scores of evaluation objects are $S_i = \dfrac{D_i^-}{D_i^+ + D_i^-}$.

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4. Entropy weight Model based on TOPSIS

4.1. Model building

Order quantity STD, supply quantity STD and deviation STD are positively processed. Because they are extremely small indicators, they need to be transformed into extremely large indicators by using the formula for forwarding processing. Then the entropy weight method is used to determine the weight, and the definition of information entropy is introduced: the hypothesis represents a certain situation that the event that may occur, and the probability of such situation.

Define $I(x) = -\ln(P(x))$, because $0 \leqslant P(x) \leqslant 1 \quad I(x) \geqslant 0$.

$$H(x) = \sum_{i=1}^{n}\left[P(x_i)I(x_i)\right] = -\sum_{i=1}^{n}\left[P(x_i)\ln(P(x_i))\right] \tag{6}$$

It can be seen from the above formula that the essence of information entropy is the expected value of information. The greater the information entropy of a random variable is, the more information its value (content) can supply [2]. The probability matrix is further calculated, where the calculation formula of each element is:

$$P_{ij} = \frac{\tilde{z}_{ij}}{\sum_{i=1}^{402}\tilde{z}_{ij}} \tag{7}$$

The information entropy of each index was calculated and the information utility value was calculated, and then the entropy weight of each index was obtained by normalization.

$$e_j = -\frac{1}{\ln n}\sum_{i=1}^{n}P_{ij}\ln(P_{ij}), \quad \begin{pmatrix} i = 1, 2, \cdots, 402 \\ j = 1, 2, \cdots, 10 \end{pmatrix} \tag{8}$$

Define information utility value: $d_j = 1 - e_j$, the larger the value is, the more information it corresponds to. By normalizing the information utility value, we can get the entropy weight of each indicator:

$$W_j = \frac{d_j}{\sum_{j=1}^{m}d_j}, \quad (j = 1, 2, \cdots, 10) \tag{9}$$

4.2. Model solving

The weight determined by entropy weight method obtained by TOPSIS combined with entropy weight method is:

Table 1: Evaluation Index weight determined by Entropy method

Order quantity STD	Order quantity MAX	Order quantity SUM	Order quantity STD	Order quantity MAX
0.1196	0.0794	0.0768	0.1196	0.0626
Order quantity SUM	Error STD	Error MAX	Error MIN	Error SUM
0.0720	0.1196	0.1113	0.1196	0.1196

As a result, we can get the supplier ranking.

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Table 2: ID of the top 50 most important suppliers

ID	Ranking	ID	Ranking	ID	Ranking	ID	Ranking	ID	Ranking
348	1	330	11	268	21	365	31	367	41
201	2	308	12	306	22	15	32	346	42
140	3	307	13	37	23	31	33	64	43
151	4	395	14	143	24	55	34	80	44
374	5	282	15	194	25	40	35	294	45
229	6	340	16	352	26	86	36	244	46
361	7	275	17	160	27	210	37	96	47
126	8	329	18	284	28	364	38	291	48
108	9	131	19	247	29	157	39	208	49
139	10	356	20	338	30	74	40	218	50

5. Optimal transfer scheme model

Assumptions for selecting transport freight to the supplier, if it supplies the $x_{ij}=1$, otherwise $x_{ij}=0$, combining with the range of the attrition rate, due to a supplier a week supply of raw materials by a transit transport, a transshipment business corresponds to a fixed supplier of attrition is random, consider producing interval for the uniform distribution of (attrition rate), In this way, the 0-1 integer programming model with the minimum loss rate can be built[3-4].

The objective function is:

$$\min f=\sum_{j=1}^{50}\sum_{i=1}^{8}x_{ij}\cdot c_{ij} \tag{10}$$

Constraints need to be considered to satisfy:

$$\begin{cases}\sum_{j=1}^{50}x_{ij}\geqslant 1, i=1,\cdots,8\\ \sum_{i=1}^{8}x_{ij}=1, j=1,\cdots,50\end{cases} \tag{11}$$

Use support vector regression (SVR): for a supplier, each time the independent variable vector X dimension is determined, the minimum dimension is 2. The data set was divided into test set and training set, and the ratio of the test set to the data set was 0.3, to evaluate the model and obtain the goodness of fit. Finally, repeat the above steps for all suppliers to obtain the forecast results of all suppliers.

The regression model is $f(x)=w^T x+b$.

Then can get $\min_{w,b}\frac{1}{2}\|x\|^2+C\sum_{i=1}^{m}l_\epsilon\left(f(x_i)-y_i\right)$. Then the relaxation variable and Lagrange multiplier are introduced [5].

$$\begin{aligned}&L\left(w,b,\alpha,\hat{\alpha},\xi,\hat{\xi},\mu,\hat{\mu}\right)\\&=\frac{1}{2}\|x\|^2+C\sum_{i=1}^{m}\left(\xi_i+\hat{\xi}_i\right)-\sum_{i=1}^{m}\mu_i\xi_i-\sum_{i=1}^{m}\hat{\mu}_i\hat{\xi}_i+\\&\sum_{i=1}^{m}\alpha_i\left(f(x_i)-y_i-\epsilon-\xi_i\right)+\sum_{i=1}^{m}\hat{\alpha}_i\left(y_i-f(x_i)-\epsilon-\hat{\xi}_i\right)\end{aligned} \tag{12}$$

Strives for the partial derivatives:

$$w=\sum_{i=1}^{m}\left(\hat{\alpha}_i-\alpha_i\right)x_i, 0=\sum_{i=1}^{m}\left(\hat{\alpha}_i-\alpha_i\right), C=\alpha_i+\mu_i, C=\hat{\alpha}_i+\hat{\mu}_i \tag{13}$$

Then substitute the above equation into the Lagrange function to obtain the dual problem of SVR

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$$\max_{\alpha,\hat{\alpha}} \sum_{i=1}^{m} y_i\left(\hat{\alpha}_i-\alpha_i\right)-\epsilon\left(\hat{\alpha}_i+\alpha_i\right)-\frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{m}\left(\hat{\alpha}_i-\alpha_i\right)\left(\hat{\alpha}_j-\alpha_j\right)x_i^T x_j \tag{14}$$

$$\sum_{i=1}^{m}\left(\hat{\alpha}_i-\alpha_i\right)=0, \hat{\alpha}_i \geqslant 0, C \geqslant \alpha_i \tag{15}$$

KKT conditions satisfied by the above formula are:

$$\begin{cases} \alpha_i\left(f\left(x_i\right)-y_i-\epsilon-\xi_i\right)=0 \\ \hat{\alpha}_i\left(y_i-f\left(x_i\right)-\epsilon-\hat{\xi}_i\right)=0 \\ \alpha_i\hat{\alpha}_i=0, \xi_i\hat{\xi}_i=0 \\ \left(C-\alpha_i\right)\xi_i=0, \left(C-\hat{\alpha}_i\right)\hat{\xi}_i=0 \end{cases} \tag{16}$$

The solution of SVR can be obtained:

$$f\left(x\right)=\sum_{i=1}^{m}\left(\hat{\alpha}_i-\alpha_i\right)x_i^T x+b \tag{17}$$

Thus, we can use this model (SVR) to solve the supply data of the top 50 suppliers in the last 24 weeks.

6. Conclusion

For the ordering and transportation of raw materials, we should focus on the production efficiency of the enterprise, that is, the purchasing cost of raw materials, the stability of supply, and the loss rate of transportation. First of all, the use of TOPSIS combined with entropy weight to give the top 50 most important suppliers, combined with the system clustering algorithm to analyze and verify that the ranking of the model is reasonable. Then the descriptive statistics related to the transportation loss rate are obtained by using the SPSS software. The 0-1 integer programming is constructed for the transfer scheme. For the enterprise ordering plan, we use the supplier data to use the support vector regression algorithm model to predict the most economical raw material ordering plan in the next 24 weeks.

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